LUETTICH, UNC-CH
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 5 PROGRESS REPORT
July 1, 2019 – June 30, 2020

I. INTRODUCTION

Project Title: ADCIRC Prediction System Development Coordination and Improved Connectivity with Hydrologic Models

Principal Investigator Name/Institution: Rick Luettich, Professor, University of North Carolina at Chapel Hill
Additional Research Participants/Partners:
Brian Blanton, UNC-CH
Jason Fleming, Seahorse Consulting,
Casey Dietrich, NCSU
Clint Dawson, UT-Austin
Scott Hagen, LSU
Isaac Ginis, URI
Don Resio, UNF

Short Project Description ("elevator speech

A substantial portion of the Coastal Resilience Center's research portfolio involves the development and application of new capabilities for the ADCIRC Prediction System (APS)^{TM} which is comprised of ADCIRC, the ADCIRC Surge Guidance System (ASGS) and the Coastal Emergency Risks Assessment (CERA) web portal. This project provides resources for the overarching coordination across the ADCIRC portfolio, from process improvements to transition.

Included in these activities are the development of:

- higher resolution regional grids for the US East and Gulf coasts that integrate with our current national scale Hurricane Surge on demand Forecast System (HSOFS) grid (with Dietrich, Dawson, Hagen, Ginis);
- software to efficiently track and manage multiple ADCIRC runs across different computer platforms including "the cloud" (with Blanton, Fleming);
- additional improvements in the wind model that is included in ADCIRC (with Ginis);
- better coupling to hydrology models that track the movement of fresh water across the land, into streams and rivers until it interacts with coastal waters (with Resio, Ginis, Huang);
- continued operation and maintenance of the ASGS and CERA to provide access to

ADCIRC predicted water levels and flooding during major storm events and water velocities 24x7x365 for US Coast Guard search and rescue operations (with Blanton, Fleming and Kaiser);

- enhanced documentation for ADCIRC via the development of an ADCIRC wiki; and
- development of a business plan and end-user outreach to support transition and self-sustainment (Tom Richardson and Jason Fleming)

This proposed project will contribute to and coordinate the suite of projects providing enhancements to the APS to increase the accuracy and power of this system; provide interpretation of APS results during major storm surge events to maximize the value of these results for end users; and develop improved documentation and testing via an updated website, wiki and test cases to better enable its use by the broader ADCIRC user community.

II. PROJECT NARRATIVE

1. Project overview:

   Significant development work has been and continues to be done to enhance the ADCIRC modeling system. This project is designed to direct and integrate this work for the benefit of ADCIRC-based forecasting system that comprises the ADCIRC Prediction System (APS). In addition, this project supports the expansion of ADCIRC information and documentation available to the user community and the development of improved couplings between inland and coastal flooding.

2. Results:

   Results are further detailed in the milestone tables below. Preeminent results include extensive forecasting efforts for 2019 hurricanes Barry and Dorian; substantial progress toward ADCIRC validation for 2018 hurricane Florence including improvements to the land interaction terms in the wind forcing model and the ability to model hydrologic flow in coastal areas; enhancements to APS capabilities including the continued development of the ASGS monitoring portal by Blanton; the development of a group of multiple individuals who are capable of operating the APS; and near completion of a business plan for the continuation of ADCIRC based forecasting after the end of the CRC.

3. End users:

   Hurricane Barry forecasts – The State of Louisiana Coastal Restoration and Protection Agency – while the Governor of Louisiana generously attributed these results to the Water Institute and LSU, APS results provided critical information used in making the decision not to evacuate the city of New Orleans in advance of this storm.

   Hurricane Dorian forecasts – These results were broadly used along the US south east coast as the storm approached and eventually move northward along the coast. During the storm I communicated with the State of Florida Emergency Command Center; Departments of Transportation in South Carolina, North Carolina and Maryland and the emergency

command center in the While House. I also provided briefing material to DHS OUP for dissemination to DHS S&T leadership.

While not all end users access APS via CERA, we have a database of over 700 individuals who have registered for CERA login credentials over the past two hurricane seasons. These users were surveyed to solicit feedback on APS existing or desired products in January / February 2020 and the results are being used to develop the APS business plan (see Richardson report).

I am on the leadership team of the interagency Coastal Coupling Community of Practice (includes NOAA, USGS, USACE, FEMA, academia, others) which forms an important community of end users for advancements in the coastal hydrologic-storm surge work.

The broader ADCIRC user community comprises a significant group of end users who have benefited from the improved ADCIRC model documentation that is being provided on the ADCIRC wiki.

4. Transition:

During significant storm events I use twitter, email, video conferencing and phone to communicate results from the APS. The Coastal Coupling Community of Practice is an important network for facilitating transition of modeling advancement, and the coastal circulation listserve and professional meetings are important means for communicating model and documentation advancement. The APS business planning project is important for developing a long term sustainability plan for ADCIRC and APS.

5. Project Impact:

The results discussed above for Hurricanes Barry and Dorian are examples of the high impact of our work. While decisions are rarely the result of a single source of information, we know that our work during Barry guided closing gates in the hurricane protection system around greater New Orleans and influenced the decision not to evacuate the city in advance of the storm. The latter decision was contentious because independent predictions made by the USACE/NWS suggested that the storm surge added on top of the historically high river stage would produce overtopping of the river levees in New Orleans. ADCIRC model runs indicated that this was unlikely to happen. I do not have a similarly explicit example of ADCIRC's role in decisions during Dorian, however, my conversations with multiple state and federal agencies in the period leading up to the storm indicated they found our results to be valuable with the myriad of decisions they were faced with before and during the storm.

6. Unanticipated Problems:

The greatest unanticipated problem has been hiring technical help for this project. Due to the substantial funding delays in year 4, I was not able to hire significant technical assistance for

this project. During year 5 I was able to identify, process and hire an outstanding individual with extensive ADCIRC development and application experience. However, delays in processing his visa (he is a Japanese citizen) delayed his arrival in the US until early 2020, after which all immigration was been shut down. I am currently looking for other help and hoping that he will be able to join our team in the US in the spring of 2021. These issues have delayed progress, particularly on the hydrologic / storm surge coupling research.

7. Student Involvement and Awards:

   a) How did you involve students in your research during Year 5, including research assistants supported or partially supported by CRC funding? Did you include non-CRC students in your research?

      Jessamine Straub, Marine Sciences MS student – studied accuracy of ADCIRC+SWAN water level and wave predictions for computing wave runup and dune erosion along different types of barrier island shore faces.

      John Ratcliff, Marine Sciences MS student – studying the accuracy of ADCIRC+SWAN for predicting storm surge and flooding from Hurricane Florence

      Taylor Asher, Marine Sciences PhD student – working on the ADCIRC wiki

      Tiana Johnson - North Carolina A&T, undergraduate, MSI 2020 summer team – modeling Hurricane Florence using the WARF meteorological model

      Jackson Wiles - North Carolina A&T, graduate, MSI 2020 summer team – modeling Hurricane Florence using the WARF meteorological model

   b) Describe the demographics (esp. minority students) and student level (undergrad, graduate, etc.) involved in your research

      Jessamine Straub – white, female, graduate

      John Ratcliff – white, male, graduate

      Tylor Asher – white, male, graduate

      Tiana Johnson - African-American, undergraduate

      Jackson Wiles - graduate

   c) List any degrees attained by CRC-supported students during Year 5. Include student name and degree (BS, MS, Ph.D.) and major or field of study.

      Jessamine Straub – awarded MS in Marine Sciences with a graduate Certificate in Natural Hazards Resilience.

   d) List any awards/recognition students achieved during Year 5.

      Jessamine Straub – awarded a Knauss Fellowship and is now working with the USACE (Julie Rosati and Mary Cialone) on coastal resilience.

8. Interactions with CRC education projects:

My project did not directly interact with one of our CRC education partners.

9. Interactions with CRC education projects:

My project is currently interacting with a summer MSI team from NC A&T University.

III. RESEARCH ACTIVITIES AND TRANSITION MILESTONES

1. Year 5 Research Activities and Milestone Achievements:

Year 5 Research Activities and Milestones: Status as of 6/30/2020

Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Continue development of hydrologic model – ADCIRC coupling to include additional ways to represent interactions in rivers	06/2020	50%	This work has been delayed by the late funding received for the project during year 4 and the difficulties hiring an individual who is a Japanese citizen due to prolonged and now halted visa processing. We will continue to work on this during year 6 using funds carried over from year 5.
Evaluate performance of new ADCIRC river representations in hydrological model – ADCIRC coupling studies by Ginis/Huang (New England) and Resio (Northern Florida).	06/2020	0%	This work has been delayed by the late funding received for all of the projects involved during year 4 and the difficulties hiring an individual who is a Japanese citizen due to prolonged and now halted visa processing. We will reconsider the feasibility of this milestone during year 6.
Research Milestone			
Presentation of findings from research activities at national conference	1/2020	100%	Presentations drawing from this work during year 5 included:

			2020 Ocean Sciences, San Diego, CA 2020 American Meteorological Society Annual Meeting, Boston, MA RISE 2019 National Conference: Transforming University Engagement in Pre- and Post-Disaster Environments, Albany, NY 2019 Making Communities More Resilient to Extreme Flooding, Earth from Space Institute, Columbia, MD (keynote speaker) 2019 American Meteorological Society Summer Community Meeting, Albany, NY (invited)
Presentation of findings from research activities at ADCIRC Week	06/2020	100%	done by graduate student Taylor Asher
Submission of manuscript about hydrological model – ADCIRC coupling for peer review	06/2020	0%	to be done in year 6

2. **Year 5 Transition Activities and Milestone Achievements**:

Year 5 Transition Activities and Milestones: Status as of 6/30/2020

Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Modify ADCIRC / ASGS to interface with the URI HBL	06/2020	0%	This work has been delayed by both the late funding received by both the UNC and URI projects during year 4 and hiring difficulties. We will pursue this during year 6 using funds carried over from year 5.

Transfer of version 2 of high resolution regional grids into APS to include improved hydrologic coupling in rivers and to address improvements identified during testing and application of version 1 of these grids during 2019	06/2020	100%	5 regional grids have been transitioned for use in the APS forecast runs.
Test capability of ADCIRC / ASGS run monitoring portal	06/2020	100%	The APS run monitoring portal was tested and extensively utilized during the 2019 hurricane season.
Continued revision of ADCIRC website and documentation available online at adcirc.org to include an ADCIRC wiki page and additional test cases for the benefit of the ADCIRC user community.	06/2020	100%	Extensive progress has been made revising the ADCIRC documentation via the ADCIRC wiki and the inclusion of additional ADCIRC test cases.
Transition Milestone			
Inclusion of URI HBL wind model in ADCIRC / ASGS Version 2 of high resolution grids included in APS	06/2020	50%	This work has been delayed by both the late funding received by both the UNC and URI projects during year 4 and hiring difficulties. We will pursue this during year 6 using funds carried over from year 5.
Version 2 of ADCIRC / ASGS run monitoring portal is operational	06/2020	100%	
Version 2 of revised ADCIRC website and documentation available online at adcirc.org	06/2020	100%	

3. **Research Project Product Delivery.**

Table: Research Project Product Delivery

Product Name and Function	**Brief Product Description, including type** (e.g., software, algorithm, guidance document, knowledge product)	**Date Delivered** (or projected date of delivery)	**Recipient or End User(s)**
ADCIRC version 54	software	Spring 2020	ADCIRC User Community
http://wiki.adcirc.org	Wiki documentation	Summer 2020	ADCIRC User Community

IV. PUBLICATIONS AND METRICS

1. Publications:

a)

2020 Luettich, R.A. and D.R. Corbett, "Sea Level Rise and Coastal Water Levels", chapter 4 in Kunkel, K.E., D.R. Easterling, A. Ballinger, S. Bililign, S.M. Champion, D.R. Corbett, K. Dello, J. Dissen, G.M. Lackman, R.A. Luettich, Jr., L.B. Perry, W.A. Robinson, L.E. Stevens, B.C. Stewart, A.J. Terando, 2020: North Carolina Climate Science Report. North Carolina Institute for Climate Studies, 232 pp. https://ncics.org/nccsr.

2020 Straub, J.A., A.B. Rodrigueq, R.A. Luettich, L.J. Moore, M. Itzkin, J.T. Ridge, A.C. Seymour, D.W. Johnston, E.J. Theuerkauf, "The role of beach state and the timing of pre-storm surveys in determining the accuracy of storm impact assessments", Marine Geology 425(2020), https://doi.org/10.1016/j.margeo.2020.106201.

2020 Gharagozlou, A., J.C. Dietrich, A. Karanci, R. Luettich, M.F. Overton, "Storm-Driven Erosion and Inundation of Barrier Islands from Dune- to Region-Scales", *Coastal Engineering*, 158(2020), https://doi.org/10.1016/j.coastaleng.2020.103674.

2019 Asher, T.G., R.A. Luettich Jr., J. Fleming, B.O. Blanton, "Low frequency water level correction in storm surge models using data assimilation", *Ocean Modelling*, 144(2019): 101483. https://doi.org/10.1016/j.ocemod.2019.10148

2019 Paerl, H.W., N.S. Hall, A.G. Hounshell, R.A. Luettich, Jr., K.L. Rossignol, C.L. Osburn, J. Bales, "Recent increase in catastrophic tropical cyclone flooding in coastal North Carolina, USA: Long-term observations suggest a regime shift", *Nature Scientific Reports*, (2019) 9:10620, https://doi.org/10.1038/s41598-019-46928-9

2019 Thomas, A., J.C. Dietrich, T.G. Asher, M. Bell, B.O. Blanton, J.H. Copeland, A.T. Cox, C.N. Dawson, J.G. Fleming, R.A. Luettich, "Influence of Storm Timing and Forward

Speed on Tides and Storm Surge during Hurricane Matthew", *Ocean Modeling*, v137, May 2019:1-19, doi.org/10.1016/j.ocemod.2019.03.004.

2018 Gao, J., On the Surface Wind Stress for Storm Surge Modeling, PhD Dissertation Department of Marine Sciences, UNC Chapel Hill, 12/2018, primary advisor – R. Luettich.

b)

2019 Straub, J.A., Predicting Dune Erosion at Dissipative, Intermediate and Reflective Beaches, MS Thesis, Department of Marine Sciences, UNC Chapel Hill, 7/2019, primary advisor – A. Rodriguez.

2. Performance Metrics

N/A